Flipping the classroom

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Flipping the classroom: an effective approach to deal with diversity at higher education

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ABSTRACT

Even though the flipped classroom is an increasingly popular method in education, a literature search shows a gap in research on this method in higher education. This article describes an experiment with two central questions: (1) How do students and lecturers assess the effectiveness of the FC method? And (2) What are crucial design elements? To be able to answer these questions we designed an experiment within a large-size, interdisciplinary, course. For three years we carefully monitored and evaluated the course. A mixed-method approach was used to collect data. Our findings show a positive contribution of the FC approach to the learning experience of students. We also found that a strong link between theory and practice is essential in the course design; combined with active learning we were able to involve students and stimulate them to reach a deeper level of understanding. Moreover, we believe that the FC approach offers opportunities to have a large interdisciplinary group, with different learning needs, work together on higher attainment levels.

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Interdisciplinary; flipped classroom; self-pacing; cognitive load; higher education

Introduction

Flipped Classroom (FC) is an increasingly popular method in education (Bergmann & Sams, 2012; Chen, Wang, Kinshuk, & Chen, 2014; Sams & Bergmann, 2013). Although the principles of Flipped Classroom approach are older, the term Flipped Classroom was introduced by Aaron Samms and Jonathan Bergmann in 2007. They describe a method that shifts the responsibility for learning from the teachers to the students, that increases interaction between teachers and students and that stimulates active learning (Bergmann & Sams, 2012). Typically, a FC approach in based on pre-recorded video's that students can access prior to in class activities. By watching the videos, students get the opportunity to prepare, at their own pace, in order to participate in active learning activities, such as debates, quizzes, and group discussions during in-class time (Davies, Dean, & Ball, 2013; Fulton,

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2012; Kim, Kim, Khera, & Getman, 2014; Pierce & Fox, 2012; Zappe, Leicht, Messner, Litzinger, & Lee, 2009).

Various benefits are described to FC: it stimulates active learning, increases interaction between teachers and students, reaches a deeper level of understanding of students and the approach shifts responsibility for learning towards the students (Bergmann & Sams, 2012; Tune, Sturek, & Basile, 2013). Abeysekera and Dawson (2014) proposes that flipped classroom helps students in their learning process by the reduction of cognitive load by self-pacing and providing opportunities that fit the highly varied needs in student populations (Abeysekera & Dawson, 2014). According to Mason, Shuman, and Cook (2013) and Wilson (2013) there is increasing indirect evidence, such as increased course grades and student satisfaction, promoting the flipped learning approach. O'Flaherty and Philips (2015) further indicates that flipped classroom enables universities to provide a cost effective, student centered education.

In contrast to the enormous amount of research conducted at the primary and secondary (K12)-level very little research has been conducted at the level of higher education. Abeysekera and Dawson (2014, p.11) argue that "for individual university teachers to be confident in the flipped approach, and university decision-makers to" support it is necessary to conduct more research. Chen et al. (2014) mentioned that "… the flipped model is still underutilized and underexplored in the higher education context and that design models for flipped learning in higher education are also insufficient." Moraros, Islam, Yu, Banow, and Schindelka (2015) argues that we need to know more about the effectiveness of FC approach. Various researchers thus emphasize the urgent need to conduct more research on flipped classroom in higher education (Abeysekera & Dawson, 2014; Chen et al., 2014; Jensen, Kummer, & Godoy, 2014; Moraros et al., 2015).

In this article, we describe the lessons learnt from a Flipped Classroom experiment within a course in the two-year interdisciplinary master's program "Management Policy Analysis and entrepreneurship in the health and life sciences" (MPA), offered by the VU University, Amsterdam, the Netherlands. This program aims to prepare researchers, who can conduct research at the interface of science and society, and who can contribute to solving complex societal issues related to the health and life sciences. Students with bachelor of science degree (such as biology, medical biology, health sciences, or medicine) can enter the program and in the program the knowledge and skills of the students are broadened to disciplines such as, "Science, Technology and Society Studies", "Science Policy", and "Management Studies". During the second course of the program, students are trained in concepts, models and theories from the policy arena. Course evaluations of this course showed that students perceived the exam as difficult, lecturers observed a gap between explaining the theoretical models in lectures and applying these theories. Tailoring the message was perceived as difficult due to the diverse disciplinary backgrounds of the students. Based on the evaluations the educational team redesigned the course to a FC approach.

In this article, we address two questions, first if the FC approach is effective for dealing with diversity of students, as seen from the perspective of both the students, and the lecturers and second what are crucial design elements of the approach to make it successful. We first describe the course in which we conducted the experiment. Next, we describe the FC approach and the methodology. After which we present the major results. Finally, we discuss our findings in relation to theory.

The original course

The course "Analysis of Governmental Policy" is the second compulsory 4-week course of the masterprogram. The aims of the course are to (1) learn and apply concepts, models and theories from the policy arena, (2) to integrate knowledge and skills from other disciplines. The course consists of traditional lectures on theoretical concepts and models concerning policy analysis provided by a full professor, in which students obtain knowledge on policy theories and models. Parallel to the lectures the students in groups of 10 apply and practice these theories in "Community Service Projects". Students are confronted with a real policy problem from an external commissioning community service organization (e.g., a civil society organizations, health organizations, municipalities, Ministries, or advisory council). Within 4 weeks they collect data by literature review and interviews and conduct an interdisciplinary analysis on the basis of which they provide an advice. Specific attention is paid to working in a project team and team building. At the end of the course, students prepare an advisory report. On the last day of the course this report is presented to the representative of the external institution who commissioned the project.

The redesigned course: the flipped classroom experiment

Students and lecturers indicate that the experience from practice gained during the Community Service Projects contributed most to their learning. Also, students preferred to spend most time on the projects as they wanted to provide an excellent product to the commissioning party. However, lecturers noticed that quite a number of students faced difficulties to grasp the theory (partly because of their diverse backgrounds). This is in line with comments of some students who indicated that the lectures were difficult to understand. Therefore, it was decided to change the traditional lectures and improve the links between theory and practice. In order to keep the academic quality of program, the management of the program considered it of utmost importance to keep (or even strengthen) the opportunity of the students to discuss with a full professor. Since it was impossible to have the professor in front of all 20 workgroups, it was decided to keep the contact hours in the large size class, but to change the traditional lectures to so called "masterclasses" (see below).

The policy theory was explained in a total of 10 mini-lectures, which were recorded on video (12–25 min each). Each mini-lecture highlights the main concepts of the corresponding book chapter, illustrated with real life examples. The mini lectures were developed by the professor involved in the course and recorded by the Audio Visual Center of the University. PowerPoint slides were shown simultaneously with the lecture. The videos were made available via the blackboard page of the course. Students could rewind and watch as often as they liked.

Contact hours that were previously used for traditional lecturing were now used for masterclasses of 2–4 h. Masterclasses aimed to stimulate in-depth discussions about the theory and integrating theory into practice and were led by professors and field experts. Central in these discussions were the team projects that students worked on parallel to the theory part of the course. Each masterclass was structured differently with assignments used to stimulate discussion and to address the link between theories and practice (see Box 1). In order to be able to compare the outcomes of year 2014 and 2015, the lecturer, videos, book, mock exam and type of exam questions remained unchanged. In this research, we only assessed the masterclasses and videos (not the practical component).

Methodology

The FC experiment was conducted in October 2014 and 2015, with, respectively, 136 and 116 students. To study the effects of the flipped classroom experiment, and to assess what were the crucial design elements, we carefully monitored and evaluated the experiment. Therefore, we applied a mixed-method approach.

Data collection 2014

We collected various quantitative data. First, we assessed the server data, which consisted of the number of views videos, repetitions per video, the duration of the views per video, and specific times on which videos were viewed. Secondly, students were asked to fill out the survey questions with additional open-ended questions to obtain in-depth information about their learning behavior and their perceptions towards the masterclasses and FC. In total, 130 students (out of 136; 96%) filled out the questionnaire. The results were analyzed using Excel; next to descriptive analyses a two sample t-test, Mann-Whitney test, Chi-square test and one-way Anova were used. Finally, a comparison was made with the outcome of the routine course assessment of the VU University course of 2014 with the one of 2013 (original course design).

We also investigated the perceptions of students and lecturers in the effectives of the FC approach and design in a qualitative approach. 26 students participated in a semi-structured interview in 2014. Two students of each project team (13 teams in total) were randomly selected and invited by e-mail to participate in an interview. Also the lecturer was interviewed about the effectiveness of the approach

and the design of the FC experiment. Moreover, three students that participated in the course in October 2013, – with the original course design – were invited to watch the videos and attend the masterclasses in October 2014. These observing students participated in an in-depth group interview. Henceforth, these students are called "observers". Each interview was converted to text through verbatim transcription. The textual data were analyzed by means of qualitative content analysis, using the qualitative data analysis software MAXQDA, version 11.

Data collection 2015

On the basis of the findings of the course in 2014, changes were made to the FC design. In 2015 we evaluated the effect of these changes using a questionnaire and course evaluation. After the course in 2015, a survey was send to the students of the 2015 cohort. A total 57 students (out of 116; 49%) filled in this survey. We also compared the passing rates and the average grades of the students of 2013 (original design) with 2014 and 2015. In addition, we statistically assessed the relation between video viewing behavior to the exam grades. For an overview of the data collection, see Table 1.

Results

In this section present the results of the FC experiment. We first present the results of the data collection of 2014, next we discuss the changes made to the design and finally the outcome of the survey of 2015.

Results 2014

General perspective

We asked the perspectives of students whether specific items in the course (e.g., video, book and/or masterclass) contributed to the understanding of students (see Figure 1). With the exemption of the masterclasses all aspects contributed to the comprehension of the course material, most notably the videos (37% strongly agreed and 47% agreed) and the combination of book, video and masterclasses (22% strongly agreed and 58% agreed). The combination was also considered a good preparation of the exam (9% strongly agree, 50% agreed) and showed that

Table 1. Mixed methods used in the experiment with the FC in 2014 and 2015.

Methods used	Students	Teachers	Overall
October 2014	Server data of all students 130 questionnaires 26 interviews 1 group interview with 3 observers	Interviews	Course evaluations Exam grades
October 2015	57 questionnaires		Course evaluations Exam grades

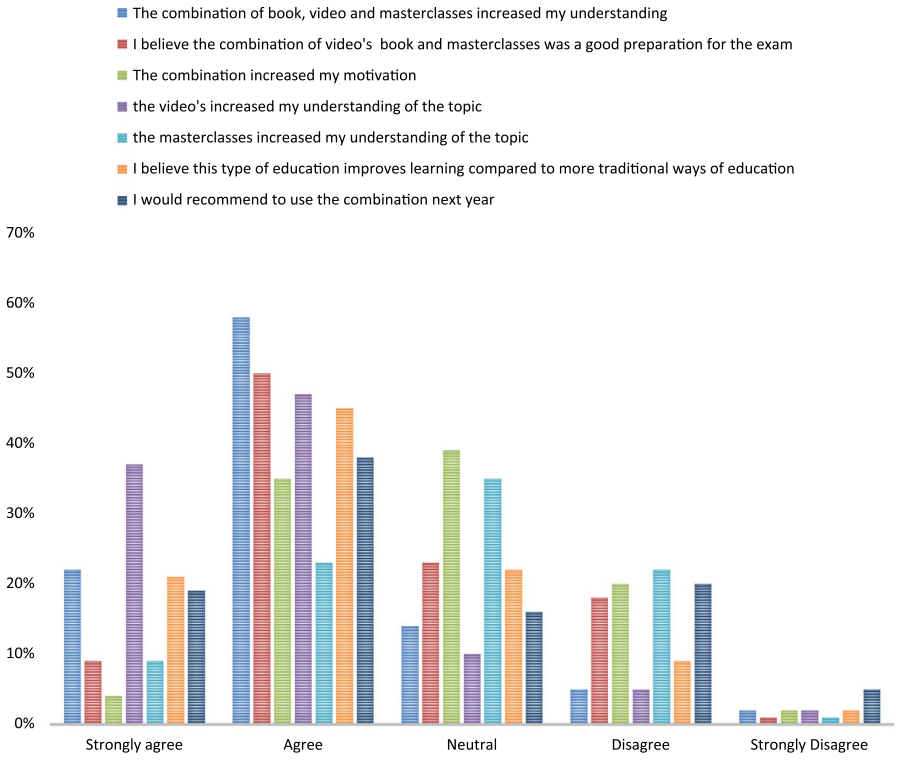

Figure 1. Indication of the extent to which course elements contributed to learning of the students, 2014, $N = 129$.

it either slightly improved their motivation or stayed neutral (4% strongly agreed, 35% agreed, 39% neutral). Students indicated whether they thought this type of education contribute more to learning than traditional education (21% strongly agreed, 45% agreed)and would recommend to use the combination next year (19% strongly agreed, 38% agreed).

Students also ranked the aspects of the course by their usefulness. As shown in Figure 4 where we compare data from 2014 and 2015, it is clear that watching videos, the book and the mock exam blog were rated most useful. In interviews, students indicated that they experienced the flipped classroom approach as an added value to their learning process.

> …we as a group read the book, watched the videos and completely submerged into it. So you have been working on that a lot better than what you normally would have done. (I10, R1)

The "observers" students saw a large, very positive, change after implementing the new instructional design. They observed increased interaction. They appreciated the videos and in combination with the masterclasses they believed that the students reached a high level of understanding of the theory.

> With such a masterclass you see it [the theory] coming back again, it is shown how you can apply it, you get more insight in the whole picture. (second year student 3)

The comparison of the routine course assessment of the VU University course of 2014 with the one of 2013 shows a equal or higher score on a 5-point Likert scale on all aspects (we do not know whether these changes are significant). Interesting is that the "clear explanation of the lecturer" increased from 2.5 to 3.54 and "important parts emphasized" increased from 2.39 to 3.55. The expectations to have failed the examination dropped from 37.2 to 17.1%.

The videos

The server data showed that the 10 available videos were viewed in total 2180 times during the first two weeks of the course in 2014. Students had the tendency to repeat views, varying from one to six times and with an average of 1.9 times per student. Fifty-seven percent of the students viewed (parts of) videos more than once. In 60% of the cases, videos were watched 90–100% of the total video duration. Before each masterclass, a peak in views is visible as well as in the days prior to the exam (see Figure 2).

The survey results confirm the findings of the viewing behavior analysis. The survey indicates a higher number of students who watched the videos; 93% of students indicated to have watched at least part of each video (79% say they watched the videos for a 100%, while the viewing statistics show that 68% of students watched all videos). During the in depth interviews with students it became apparent that some students watch the videos together on the same device. Some students made appointments at the university to watch and discuss the videos.

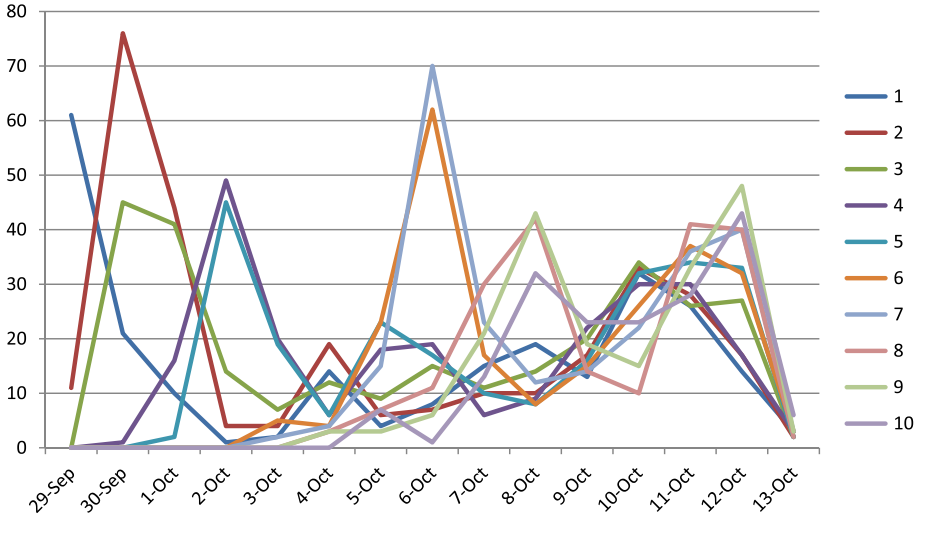

Figure 2. Number of views in 2014 per course day (*x*-axis) for each of the 10 videos (*y*-axis) used in the course.

In interviews students indicated that the videos made it easier to understand the course material and they liked that the videos were short and to the point. The possibility to stop, rewind or replay the video as often as they needed was deemed useful, as demonstrated by the following quote.

> … very handy even, because during a lecture it might go a bit too fast to follow it at all, but now you can just tap on pause and you can listen again or even co-write things down. I thought it was super convenient. (I7, R1)

Based on the qualitative and earlier discussed quantitative indicators the overall opinion of students about the videos is very positive. However, in the interviews students indicated downloading the videos was not possible, which made it impossible to watch the videos in the train, for example. Furthermore, it was indicated that the masterclasses could be better aligned to the video content. A small group of students preferred to read the book instead of watching the videos.

The lecturer indicated that he saw a big added value of the use of videos in the course. The fact that students can watch the videos more than once is very helpful, as this facilitates comprehension of concepts and theory. The lecturer did indicate that preparing and maintaining the videos is a lot of work.

The masterclasses

Survey data show that students attended on average 3.5 out of 5 masterclasses. As indicated before, survey data showed that merely 9% strongly agreed and 22% of students agreed that the masterclasses helped in improving understanding, other students were either neutral (35%) or disagreed (22%) or strongly disagreed (1%). The ranking aspect of the survey showed that the masterclasses activities, assignments, questions, explanations and Go-soap quizzes relatively scored low (see Figure 4, in which we compared the findings of year 2014 with 2015). In interviews students indicated that the workload of the project, at times, led to prioritizing project work over the masterclasses. In some instances groups send representatives to the masterclasses. However, in interviews, students – who were present during the masterclasses – consistently indicated that the discussions and exercises during the masterclasses let to deeper theoretical understanding and practical application of the course material. On the question, why the masterclasses work, the following typical answers were given.

> [during the masterclasses] you have to actively use the theory and you start thinking about it, therefore it is easier to remember. Yeah especially that you are forced to actively work with the material.

> In ordinary lectures most of the time I am just checking my phone or my laptop, and I do not pay attention. But the interactive nature [of the masterclasses] makes you really grasp the content. Making the in class assignments was also really helpful, it helped with improving understanding for the exam and the project work.

Students, observers and the lecturer experienced an improved conceptual clarity and more equal levels of knowledge prior to class between different backgrounds,

which contributed to meaningful discussions during the masterclass. During the project work this enabled students to participate in shared interdisciplinary policy analysis. Moreover, the lecturer indicated that the masterclasses allowed students to engage in meaningful discussions with him. As such, this approach helps to reach the goal of the course, to think critical about the concepts, to apply and combine them. He also experiences the interactivity as useful for teaching, since the direct feedback gives insights in the students' needs to achieve the course goals.

Adaptations in the design made to the FC after 2014

After 2014, we carefully analyzed the results and evaluated the course. The use of videos was rated very positively, but could be made more accessible offline. The added value of the masterclasses was underlined by the observers, most students that attended the masterclasses and the lecturer. Nevertheless, many students did not attend the masterclasses, partly because they prioritized working on the project and the assignments within the masterclasses were regarded detached from the projects. Therefore, we made two principal changes; (1) as technical adaptation in the course we offered the videos as downloadable file to increase flexibility for the students; (2) groups needed to use their projects as cases to apply theory in the masterclass assignments. In addition, in 2015 student teams worked on answering and (mandatory) blogging mock exam answers as preparation for the exam during the masterclasses.

Results of 2015

Our adaptations were effective in increasing masterclass attendance. 68% of all students attended all 5 masterclasses, with an average attendance to masterclasses of 4.59 out of 5 masterclasses (compared to 3.5 in 2014). Appreciation of the masterclasses as important in understanding also increased from 45% in 2015, to 55% in 2015 who either agreed or strongly agreed (no significance was found). Similar to 2014, nearly 90% (strongly) agreed that the videos contributed to their understanding of the topic. Also, most students (strongly) agreed (69%) indicated that the type of learning, understood as the combination of masterclasses and FC, contributed to their learning experience. The perceived effect of types of education on understanding of the course material 2015 is outlined in Figure 3.

The reported usefulness per course item between 2014 and 2015 is outlined below in Figure 4. Similar to 2014 most items were ranked in the same order as in 2014. However, two remarkable changes in ranking appeared the relative usefulness of reading the book decreased, whereas the usefulness of the Go-soap quizzes increased according to the students.

Similarly to 2014, the video viewing behavior was high among students. Over 90% of students in 2015 indicated to have watched all 10 videos at least once,

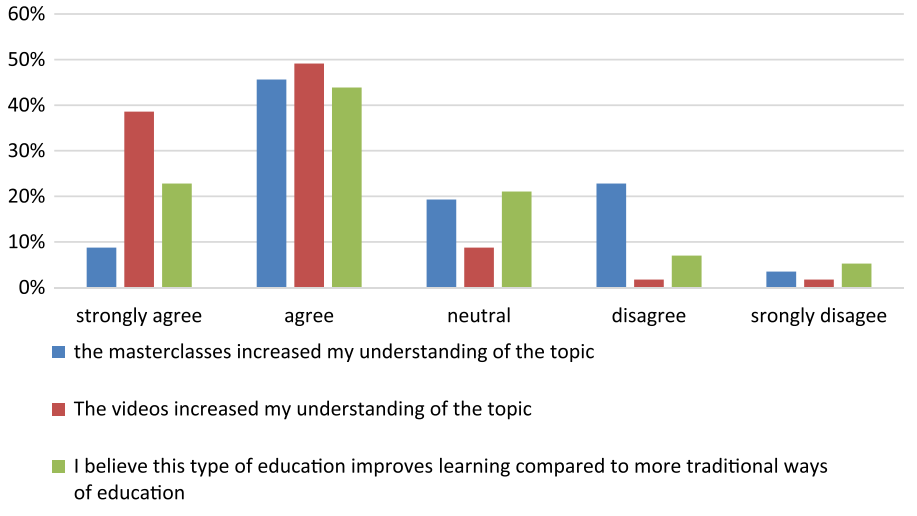

Figure 3. The perceived effect of types of education on understanding of the course material 2015, $N = 57$.

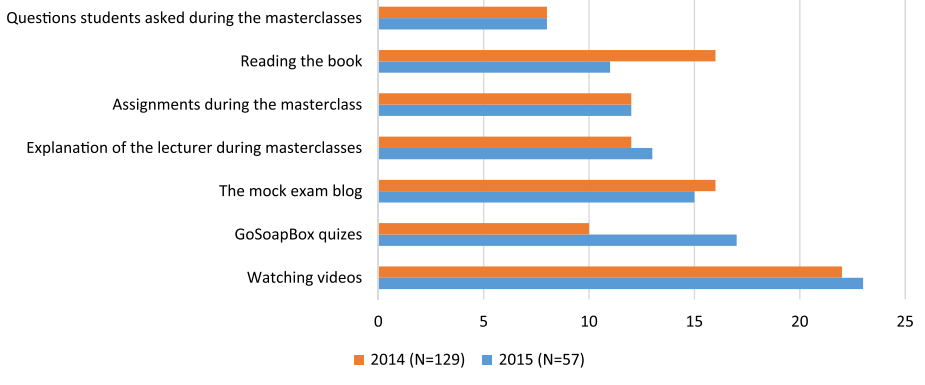

Figure 4. Usefulness of course aspects, 2014 and 2015 combined.

everybody used the rewind option and 70% watched all or some of the videos multiple times.

Success rates and grades 2013, 2014, 2015

The students were individually assessed on the theoretical part of the course. In addition they were assessed as a group on their report and participation with respect to the Community Service project. For this study, we compared only the average grade on the theoretical part of the course of the course of the cohorts 2013, 2014, and 2015 (see Table 2). Even though the grades in 2015 are lower than in 2014, both years showed a significant ($p = 0.000000003$) increase compared to 2013. We observe a higher success rate in the years 2014 and 2015 compared to 2013, although different factors attribute to the changes (e.g., different cohort).

Table 2. Comparison of grades.

	Success rate (%)	Average grade exam
2013	69.4	5.85 (2.0 – 8.4)
2014	85.4	6.60 (3.0 – 8.8)
2015	81	6.35 (2.2 – 8.7)

Box 1. Assignments used during the master classes.

- *Pitches*. Student-teams prepare, in 60 – 90 min, a 1-min pitch (PowerPoint) during the master class in which they link theory to their projects. 1 to 3 groups of students are randomly selected to pitch their work. Presentations are followed by in-depth discussions facilitated by a professor. All groups upload their pitch on the course blog.
- *Real-life cases*. The professor presents a real-life case showing complex policy problems. Students work in couples to answer three questions concerning the presented case. Each question is followed by 10 min preparation time, followed by a plenary discussion of the answers and in-depth group discussions.
- *Quizzes*. The students access quiz questions on their digital device, by using gosoapbox.com. The quizzes are used to start the discussion on specific concepts and theories from the book. Per question students have a 2–3 min to discuss the answers in couples and to provide an answer. The use of digital devices enables a good visualization of the results and thereby stimulating discussions.
- *Guest speakers*. A guest speaker presents cases on e.g., health situations in a global context, based on own experiences. Students prepare a discussion using different perspectives of actors from the field. The guest speaker facilitates in-depth discussions showing the differences in actor perspectives.
- *Mock exam questions*. During each master class each project team provide answers to mock exam questions on the digital community of the course. A lecturer provides short feedback on each answer.

An analysis in which watching the video's is compared to the exam grade per student does not reveal any influence of the behavior on the grade. Students who watch all the videos have a comparable average grade with students who watch only one or more videos. Also the number of views does not seem to affect the chance to obtain a high exam grade.

Discussion and conclusion

In this article, we addressed two questions, first if the FC approach is effective for dealing with diversity of students, as seen from the perspective of both the students, and the lecturers and second what are crucial design elements of the approach.

FC an effective approach or not?

It remains difficult to attribute positive experiences of students and their grades to the changes in the course. However, findings point in the direction of a positive contribution of this FC approach. First, the students participating in the course repeatedly indicated in surveys and interviews that they valued the course aspects and that these aspects increased understanding, most notably the use of videos. The full professor, coordinating this course for more than 10 years, confirmed this, as well as the observers. Also the official university evaluation of the course and the grades of the exam show encouraging changes. Thereby we contribute to

the body of (indirect) evidence of effective FC approaches (Gilboy, Heinerichs, & Pazzaglia, 2015; Mason et al., 2013; Wilson, 2013).

Crucial design elements

Based on our results and reflection with literature, we want to highlight a number of design elements that we think were crucial in achieving our effect. Increased integration between theory and practice through video's and masterclasses was pivotal. Previously there was limited synergy between course theory and the community service projects, and students prioritised community service work. Additionally, students struggled with the course theory due to diversity of backgrounds. After the changes in 2014, we largely resolved these issues through the flipped classroom approach. However, not all students attended the masterclasses. Therefore, in 2015 a blog was added to the masterclasses that groups of students needed to update. This contributed to preparation of and attendance to the masterclasses and increased appreciation of one of the go-soap quizzes that were pivotal in the masterclasses.

Specifically our experiment allowed more time for active learning in masterclasses. Other researchers have found that active learning improves student's achievements (Freeman et al., 2014) Scientific research already has shown a strong link between FC and active learning (Berrett, 2012; Biggs, 1999; Bonwell & Eison, 1991; Nederveld & Berge, 2015; Warburton, 2003). The overarching definition is that active learning "involves students in doing things and thinking about the things they are doing" (Bonwell & Eison, 1991; Michael, 2006). Biggs suggests an active learning approach to stimulate students who tend to have a surface learning approach to adopt a deep learning approach (Biggs, 1999). More research shows a positive relation between active learning and deep learning (Warburton, 2003), showing that active learning enables programs to maintain high academic standards (Abeysekera & Dawson, 2014).

Furthermore, we strongly believe that the *combination* of videos, masterclass and project is a valuable pedagogical design for interdisciplinary education, where students from different backgrounds have to comprehend similar theory. These students have different prior knowledge and skills and therefore different learning needs to reach the final attainment levels (Biggs & Tang, 2011; Cook, 2006; Sweller, 1994; Zweekhorst, Konijn, Broerse, & Maas, 2015). Van Merriënboer and Sluijsmans (2009) argue that the complex learning tasks that accompany interdisciplinary learning create a high cognitive load, it might even cause an excessive load for novice students (Van Merriënboer & Sluijsmans, 2009). If might be that our approach enables students to better manage the cognitive load by self pacing (rewinding and re-watching of the videos). Therefore, students with a diverse background could engage in meaningful discussions and reflection of the theory to practice and vice versa. This was observed by the lecturer and the observers during the

masterclass and in the outcome of the project. This resulted in a positive effect in the assessment of the course: course evaluations showed improvements.

Specifically, we want to emphasize that FC is possible in large classrooms (100+), whereas most literature describes FC in small(er), workgroup, settings. Our approach design has two specific benefits. Videos allow for students to prepare in advance, this enables a full professor to engage with all students in large scale masterclasses. In the masterclass, second year observing students and the lecturer observed deeper and broader discussion with the lecturer and among multiple student(s) (groups). Most flipped classroom sessions are done in small settings with junior staff.

A crucial meta-design element was to closely monitor, evaluate and adapt the FC. After the first-year small changes have been made what especially had an impact on the attendance of the masterclasses; videos were made downloadable; inclusion of own project work in masterclasses.

Strengths and limitations

It is a strength of the study to monitor and evaluate three consecutive years of one particular course. However, the comparison between different cohorts remains complex and differences between cohorts can be the result of confounding factors. Nevertheless, data triangulation and data saturation increases reliability and validity of our findings. Data triangulation was done between qualitative and quantitative data of students participating in the course, observing students, teachers and exam results. A potential limitation can be the differences in the quantity of data collected for the 2014 cohort in comparison to the 2015 cohort. For example, in response to the request of the students to make videos downloadable, server data for 2015 were not available. Also, the response rate of the survey in 2014 was very high (96%) and still satisfactory in 2015 (49%).

Our data does not provide much insight into the long-term effect of the course. The most important drawback of the study was that it remains challenging to attribute the effects that we have observed to the flipped classroom adaptations. However, because we see similar and progressive improvements in both years, and positive remarks from different sources, we argue that our design is successful in this particular context.

Concluding remarks and further research

Based on all the pieces of evidence we dare to conclude that that the *combination* of videos, masterclass and Community Service Learning is a valuable pedagogical design for interdisciplinary education, in which lecturers have to deal with a wide diversity of educational backgrounds of students. Increased integration between theory and practice through video's and masterclasses was pivotal. We argue that for master-level academic education it is critical to have in depth academic

discussions with full professors or experts. Our findings show that flipped classroom is possible in large masterclasses (100+) and that interaction between students and teacher remains possible. We want to emphasize that it is needed to closely monitor, evaluate, and adapt the FC approach.

A point for further research is the development of a toolbox to support lecturers with class time activities to engage with large size classes. Concrete tools are necessary, considering that not all teachers are highly trained in large group facilitation, while facilitation skills seem to be crucial for the success of the flipped classroom approach in large groups. It is furthermore important to assess whether this approach also benefits disciplinary (master) programs and bachelor programs?

Disclosure statement

No potential conflict of interest was reported by the authors.

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References

Abeysekera, L., & Dawson, P. (2014). Motivation and cognitive load in the flipped classroom: Definition, rationale and a call for research. *Higher Education Research & Development, 34*(1), 1–14. doi:10.1080/07294360.2014.934336

Bergmann, J., & Sams, A. (2012). *Flip your classroom; reach every student in every class every day*. Washington, DC: International Society for Technology in Education.

Berrett, D. (2012). How "Flipping" the classroom can improve the traditional lecture. *The Chronicle of Higher Education, 78*(1), 36–41. doi: 10.1108/17506200710779521

Biggs, J. (1999). What the student does teaching for enhanced learning. *Higher Education Research & Development, 18*(1), 57–75. doi:10.1080/0729436990180105

Biggs, J., & Tang, C. (2011). *Teaching for quality learning at university* (4th ed.). (p. 389). Berkshire: McGrawHill.

Bonwell, C. C., & Eison, J. A. (1991). *Active learning: Creating excitement in the classroom*. Washington, DC: Jossey-Bass.

Chen, Y., Wang, Y., Kinshuk, N.-S., & Chen, N. N. (2014). Is FLIP enough? Or should we use the FLIPPED model instead? *Computers & Education, 79*, 16–27. doi: 10.1016/j.compedu.2014.07.004

Cook, M. P. (2006). Visual representations in science education: The influence of prior knowledge and cognitive load theory on instructional design principles. *Science Education, 90*(6), 1073–1091. doi:10.1002/sce

Davies, R. S., Dean, D. L., & Ball, N. (2013). Flipping the classroom and instructional technology integration in a college-level information systems spreadsheet course. *Etr&D-Educational Technology Research and Development, 61*(4), 563–580. doi:10.1007/s11423-013-9305-6

Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the National Academy of Sciences, 111*(23), 8410–8415. doi:10.1073/pnas.1319030111

Fulton, K. (2012). Upside down and inside out: Flip your classroom to improve student learning. *Learning & Leading with Technology, 39*(8), 12–17.

Gilboy, M. B., Heinerichs, S., & Pazzaglia, G. (2015). Enhancing student engagement using the flipped classroom. *Journal for Nutrition Education and Behavior, 47*(1), 109–114. doi:10.1016/j.jneb.2014.08.008

Jensen, J. L., Kummer, T. A., & Godoy, P. D. (2014). Improvements from a flipped classroom may simply be the fruits of actve learning. *Cbe-Life Sciences Education, 14*(1), 1–12.

Kim, M. K., Kim, S. M., Khera, O., & Getman, J. (2014). The experience of three flipped classrooms in an urban university: An exploration of design principles. *Internet and Higher Education, 22*, 37–50. doi:10.1016/j.iheduc.2014.04.003

Mason, G., Shuman, T., & Cook, K. (2013). Comparing the effectiveness of an inverted classroom to a traditional classroom in and upper divison engineering course. *IEEE Transactions on Education, 56*(4), 430–435. doi:10.1109/TE.2013.2249066

Michael, J. (2006). Where's the evidence that active learning works. *Advances Physiology Education, 30*, 159–167.doi:10.1152/advan.00053.2006

Moraros, J., Islam, A., Yu, S., Banow, R., & Schindelka, B. (2015). Flipping for success: Evaluating the effectiveness of a novel teaching approach in a graduate level setting. *BMC Medical Education, 15*(1), 1–10. doi:10.1186/s12909-015-0317-2

Nederveld, A., & Berge, Z. L. (2015). Flipped learning in the workplace. *Journal of Workplace Learning, 27*(2), 162–172. doi:10.1108/JWL-06-2014-0044

O'Flaherty, J., & Philips, C. (2015). The use of flipped classrooms in higher education: A scoping review. *The Internet and Higher Education, 25*, 85–95. doi:10.1016/j.iheduc.2015.02.002

Pierce, R., & Fox, J. (2012). Vodcasts and active-learning exercises in a "Flipped Classroom" model of a renal pharmacotherapy module. *American Journal of Pharmaceutical Education, 76*(10).

Sams, A., & Bergmann, J. (2013). Flip your students' learning. *Technology-Rich Learning Pages, 70*(6), 16–20.

Sweller, J. (1994). Cognitive load theory, learning difficulty, and instructional design. *Learning and Instruction, 4*, 295–312. doi:10.1016/0959-4752(94)90003-5

Tune, J. D., Sturek, M., & Basile, D. P. (2013). Flipped classroom model improves graduate student performance in cardiovascular, respiratory, and renal physiology. *Advances in Physiology Education, 37*(4), 316–320. doi:10.1152/advan.00091.2013

Van Merriënboer, J. J. G., & Sluijsmans, D. M. A. (2009). Toward a synthesis of cognitive load theory, four-component instructional design, and self-directed learning. *Educational Psychology Review, 21*(1), 55–66. doi:10.1007/s10648-008-9092-5

Warburton, K. (2003). Deep learning and education for sustainability. *International Journal of Sustainability in Higher Education, 4*(1), 44–56. doi:10.1108/14676370310455332

Wilson, S. G. (2013). The flipped class: A method to address the challenges of an undergraduate statistics course. *Teaching of Psychology, 40*(3), 193–199. doi:10.1177/0098628313487461

Zappe, S., Leicht, R., Messner, J., Litzinger, T., & Lee, H. (2009). "Flipping" the classroom to explore active learning in a large undergraduate course. *Proceedings of the 2009 American Society for Engineering Education Annual Conference and Exhibition*.

Zweekhorst, M. B. M., Konijn, W. S., Broerse, J., & Maas, J. (2015). Inquiry-based learning in action: Reflections on an interdisciplinary master's program in the health and life sciences. *Inquiry-Based Learning for Science, Technology, Engineering, and Math (Stem) Programs: A Conceptual and Practical Resource for Educators,* 171–191. doi:10.1108/S2055-364120150000004011